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GRAND RIVER BASIN WATER MANAGEMENT STUDY TECHNICAL REPORT SERIES

DISCOUNTING PROCEDURES IN BENEFIT COST ANALYSIS TECHNICAL REPORT No. 23

GRAND RIVER IMPLEMENTATION COMMITTEE

GRAND RIVER BASIN WATER MANAGEMENT STUDY

TECHNICAL REPORT SERIES

DISCOUNTING PROCEDURES IN BENEFIT-COST ANALYSIS

TECHNICAL REPORT NO.23

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Prepared by:

M.Fortin,Economic Systems Group,
Grand River Basin Water Management Study

TABLE OF CONTENTS

Chapter		Page
	Abstract	(i)
1	Introduction	1
2	Mechanics of Discounting	2
	2.1 Future Value	2
	2.2 Present Value	3
	2.3 "Carrying Costs"	4
	2.4 Base Year	4
	2.5 Discounting Factors	6
	2.6 Examples of Discounting Exercises	7
3	Why Bother Discounting	9
4	Inflation and the Discount Rate	12
	4.1 General	12
	4.2 Inflation, Saving and Borrowing	13
	4.3 Ignore Inflation?	15
Appendix	The Choice of the Discount Rate for Canadian Projects: A Short Statement of The Issues. by Dr. C. Southey	19

LIST OF TABLES

Table		Page
2.1	Discounting Factors	5
2.2	The Present Value of a Reservoir that Costs $46 million	8
2.3	Net Present Value Calculation for a Reservoir Project Costing $46 million	9

Abstract

This report is one of a series of technical documents prepared as part of the Grand River Basin Water Management Study for the Grand River Implementation Committee. The report presents a brief discussion of discounting in benefit-cost analysis. An explanation of discounting is followed by a discussion of the relationship between inflation and discounting. The selection of an appropriate discount rate is discussed in the appendix.

Questions with respect to the contents of this report should be directed to the Co-ordinator of the Grand River Basin Water Management Study, Grand River Conservation Authority, 400 Clyde Road, Cambridge, Ontario.

1. INTRODUCTION

This report presents a brief discussion of discounting in benefit-cost analysis. Discounting is a procedure devised by economists to enable a direct comparison of monetary costs and benefits incurred at various times in the future. Drawing its justification from the behaviour of decision makers in the private sector, it is a basic and indispensible tool of planners in the public sector.

The importance of discounting in the public sector derives from the need to allocate investments funds effeciently in order to obtain the greatest possible benefit from limited resources. One means of achieving this end entails the selection of actions which minimize dollar costs or maximize net dollar benefits. In water resources planning, costs will include capital, operating and maintenance expenditures for projects such as reservoirs, sewage treatment facilities, municipal water supply projects, etc; while benefits will arise from reductions in flooding, from improvements in commercial fisheries, etc. These costs and benefits typically extend well into the future. Planners as a result, select long planning horizons for water resources studies - 50 years is common. Information on costs and benefits that occur over a 50 year period can easily lead to erroneous conclusions if not analysed using correct discounting procedures. Discounting is therefore, an important topic in the field of water resources planning.

In a section following this introduction, the reader is familiarized with the mechanics of discounting. Then comes an explanation or defense of discounting followed by a discussion of the relationship between inflation and discounting. These sections are meant for readers who have little or no background in the study of economics. A more difficult discussion considering the selection of an appropriate discount rate is included as an appendix.

2. MECHANICS OF DISCOUNTING

Discounting is a straight-forward mathematical procedure that is analogous to an interest rate calculation. In fact, it uses a rate, called the discount rate, that is determined by reference to interest rates in financial markets.

2.1) Future Value

For purposes of illustration, let us assume a discount rate of .10 or 10 percent per year. For an interest calculation, this rate is multiplied by the amount of the loan or debt, say $100.00 to determine interest earnings in one year's time:

$$.1 \times \$100 = \$10$$

If the $100 is a term deposit, then the value of the deposit in one year is:

$$\$100 + (.1 \times \$100) = \$100 \times (1.0 + .1) = \$110$$

After two years, the cumulative value of the deposit is:

$$\$110 + (.1 \times \$110) = \$110 \times (1.0 + .1) = \$121$$

or

$$\$100 \times (1.0 + .1) \times (1.0 + .1) = \$100 \times (1.0 + 1)^2$$
$$= \$100 \times 1.21 = \$121$$

By this simple procedure, we have determined this deposit's <u>future value</u> or we have <u>carried</u> the $100 deposit <u>forward</u> into the future.

When discounting for a planning study, dollar benefits and costs can similarly be carried forward. Let x represent our cost or benefit and r our discount rate. The the future value (FV) of X in 2 years is

$$FV(x) = x(1 + r)^2$$

In n years it is

$$FV(x) = x(1 + r)^n$$

If it is necessary to compare a present cost of x dollars to a return in n years of y dollars, the comparison is made using future values. The benefit, y, is compared to the future value of the cost to determine the economic worthiness of the expenditure. If y exceeds the future value of x then the expenditure is economically justifiable.

2.2) Present Value

An alternative procedure that is equivalent to carrying costs and benefits forward is customarily used in benefit-cost analysis. This is called bringing costs and benefits back to the present date or estimating the present value.

When costs are carried forward, the effect of cumulative or compound interest rate calculations tends to be explosive. For example our $100 deposit has a future value in 50 years of $11,739. Such numbers can be misleading to persons not accustomed to economic analyses. This explains a need for the convention of using present values rather than future values in planning work; since, in terms of worth, present values are directly comparable to current budgets and expenditure levels.

The present value calculation is the inverse of the future value calculation. To estimate a future value, we multiply a present value by a power function of a discount rate plus one:

$$FV(x) = x(1 + r)^n$$

To estimate a present value (PV) we divide a future value by a power function of a discount rate plus one:

$$PV(Y) = y/(1 + r)^n$$

The magnitude of a value is increased by future value calculations and diminished by present value calculations. This in essence is all that discounting amounts to.

2.3) "Carry Costs"

A sceptic among the readers is probably asking himself the question, "What about carrying costs?" Any mortgage holder will of course be all too familiar with carrying costs - the interest charges on a loan. When an expenditure is carried forward, in effect we are adding in the carrying costs in order to estimate the future value. This is the whole point of the interest rate calculation. The reverse procedure, discounting back to the present, is doing the same thing but in a different manner. Rather than adding up carrying costs of curent expenditures it is deleting those carrying costs that are avoided by delaying expenditures into the future. The annual carrying cost of $100 is $10. The present value of $100 spent next year is $100 minus one years worth of avoided carrying costs, or $90. Thus, discounting accounts for carrying costs.

2.4) Base Year

Hopefully the reader is convinced and is prepared for a further wrinkle in the fabric. We have discussed present values and future values, arguing that these are equivalent summary measures of values spread through time. Either can correcty be used for economic analysis though they may have different practical merits. The reference point in time, the future year or the present year, is the base year for the planning study. In fact, this base year is not limited to the present year or the final year of the planning horizon. Any year will do, provided that all values, future and present are converted into the corresponding values of the base year. For example, if the base year is five years hence, present and near-future benefits and costs are carried forward to this year while future values are brought back to it. Determination of a base year is a matter of convenience in a planning study. In the Grand River Basin Water Management Study, the economic analyses were performed during 1979 and 1980 and 1980 was chosen as the base year. All costs and benefits incurred between 1980 and the end of the planning horizon 2031 are, therefore, discounted back to 1980.

TABLE 2.1 Discounting Factors *

Dis-count Rate	Time Horizon Years 5	10	15	20	25	30	35	40	45	50
0.01	4.902	9.566	14.004	18.226	22.243	26.066	29.703	33.163	36.456	39.588
0.02	4.808	9.162	13.106	16.679	19.914	22.844	25.499	27.903	30.08	32.052
0.03	4.717	8.786	12.296	15.324	17.936	20.189	22.132	23.808	25.254	26.502
0.04	4.63	8.435	11.563	14.134	16.247	17.984	19.411	20.585	21.549	22.342
0.05	4.546	8.108	10.899	13.085	14.799	16.141	17.193	18.017	18.663	19.169
0.06	4.465	7.802	10.295	12.158	13.55	14.591	15.368	15.949	16.383	16.708
0.07	4.387	7.515	9.746	11.336	12.469	13.278	13.854	14.265	14.558	14.767
0.08	4.312	7.247	9.244	10.604	11.529	12.158	12.587	12.879	13.077	13.212
0.09	4.24	6.995	8.788	9.95	10.707	11.198	11.518	11.726	11.861	11.948
0.1	4.17	6.759	8.367	9.365	9.985	10.37	10.609	10.757	10.849	10.906
0.11	4.102	6.537	7.982	8.839	9.348	9.65	9.829	9.936	9.999	10.036
0.12	4.037	6.328	7.628	8.366	8.784	9.022	9.157	9.233	9.276	9.301
0.13	3.975	6.132	7.303	7.938	8.283	8.47	8.572	8.627	8.657	8.673
0.14	3.914	5.946	7.002	7.55	7.835	7.983	8.06	8.1	8.121	8.131
0.15	3.855	5.772	6.725	7.198	7.434	7.551	7.609	7.638	7.652	7.66
0.16	3.798	5.607	6.468	6.878	7.073	7.166	7.21	7.231	7.241	7.246
0.17	3.743	5.451	6.229	6.585	6.747	6.82	6.854	6.87	6.877	6.88
0.18	3.69	5.303	6.008	6.316	6.451	6.51	6.536	6.547	6.552	6.554
0.19	3.639	5.163	5.802	6.07	6.182	6.229	6.249	6.257	6.261	6.262
0.2	3.589	5.031	5.611	5.844	5.937	5.975	5.99	5.996	5.998	5.999

* Note that the inverse of these values provide factors that can be used to ammortize capital expenditures.

2.5) Discounting Factors

One final topic to consider here is the calculation of discounting factors. Readers who are unlikely to be called upon to do any discount rate calculations would do themselves a favour by skipping to section 3.

Discounting factors provide the analyst with an easy means of determining the present value of a regular stream of costs or benefits. Consider the case where an expenditure of x is incurred every year for n years. The present value of this stream of costs will be the sum of the present values of each individual expenditure:

$$PV = x + x/(1 + r) + x/(1 + r)^2 + \ldots + x/(1 + r)^{n-1}$$

This is a geometric progression which can be solved simply as follows:

$$PV/(1 + r) = x/(1 + r) + x/(1 + r)^2 + \ldots + x/(1 + r)^n$$

$$PV - PV/(1 + r) = PV(1 - 1/(1 + r))$$

$$= x - x/(1 + r)^n$$

$$PV = x(1 - 1/(1 + r)^n)/(1 - 1/(1 + r))$$

$$= x(((1 + r)^n - 1)/(1 + r)^n)/(r/1 + r)$$

$$= x((1 + r)^n - 1)/(r(1 + r)^{n-1})$$

This last line provides us with a solution for the present value of the stream of costs that does not require the estimation of the present value of each annual expenditure. The term,

$$((1 + r)^n - 1)/(r(1 + r)^{n-1})$$

is the discounting factor. It can be computed for any time period, n, and any discount rate, r, quite easily. Different conditions will alter this formula. For instance:

a) if x is growing at a rate g each year so that in year m the expenditure is

$$x(1 + g)^m$$

the discounting factor formula becomes

$$((1 + u)^n - 1)/(u(1 + u)^{n-1})$$

where

$$(1 + u) = (1 + g)/(1 + r)$$

or

$$u = (g - r)/(1 + r)$$

b) if x occurs every t years over a total period of (n)(t) years (i.e. x is intermittent), the discounting factor formula becomes

$$((1 + r)^{nt} - 1)/((1 + r)^{(n-1)t}((1 + r)^t - 1))$$

Table 2.1 gives a set of factors from the first formula given above for a range of time periods and discount rates.

2.6) Examples of Discounting Exercises

This section demonstrates the impact of discounting on future costs and benefits using data from the Grand River Basin Water Management Study. Variations in the discount rate and variations in project timing are discussed.

Consider first the construction of a reservoir in this basin. Montrose reservoir, for example, has a total construction cost of $46 million. If this reservoir were constructed now then the present value of costs would simply be $46 million (ignoring operating and maintenance costs). If construction were deferred, however, the present value of costs would be the discounted future costs. This value is estimated as:

$$\$46\ m/(1 + i)^t$$

where t gives the number of years that lapse between the current year and the implementation date. The impact of increasing t is demonstrated by reading down the columns in table 2.2.

The choice of the discount rate will affect the present vaue in an inverse manner as is evident when one reads across any row in table 2.2. This affect is more notable for large values of t. In the limit, future costs and benefits can be completely discounted to give a present value of zero, this implies an infinitely high discount rate. At the other extreme, future values are not discounted - the discount rate is zero - so that future costs or benefits are considered to be equivalent to present costs or benefits in terms of value.

TABLE 2.2 The Present Value of a Reservoir that costs $46 million*

i / t	0%	4%	6%	10%	00%
0	46	46	46	46	46
10	46	31.1	25.7	17.7	0
25	46	17.3	10.7	4.2	0
50	46	6.5	2.5	.4	0

*t = number of years until the reservoir is built
i = discount rate

Typically, project costs include large intermittent capital expenditures whereas benefits are uniformly distributed through time. In such cases the discount rate becomes an critical parameter in project evaluation. Since future sums are more heavily discounted as the discount rate increases, the present value of a stream of annual benefits will vary inversely with the discount rate. It follows obviously that the net benefit will decline for a project whose costs are current capital expenditures. This is shown in Table 2.3 using the reservoir example above and alternative values assumed for annual benefits that are assumed to accrue for 50 years.

TABLE 2.3 Net Present Value Calculations for a Reservoir Project Costing $46 million*

b \ i	0%	4%	6%	10%	00%
.2	-36	-41.5	-42.7	-43.8	-45.8
1.0	4	-23.7	-29.3	-35.1	-45
2.5	79	9.9	-4.23	-18.7	-43.3
5	204	65.7	37.5	8.5	-41

* i = discount rate

b = annual benefit in millions of dollars. Costs are a current expenditure and benefits are received annually for 50 years.

If project implementation is based on positive net benefits, then the importance of the discount rate is immediately apparent.

3. WHY BOTHER DISCOUNTING

For public sector planning studies, the practice of discounting in economic analyses can be justified by a consideration of the impact of public projects on the private sector*.

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* To simplify the exposition, non-monetary costs and benefits are not discussed but they are clearly a key factor in the selection of public sector projects. Indeed their existence motivates much of our public sector activity.

Public projects that are undertaken will draw on tax revenues which otherwise could remain in the private sector. They therefore are displacing private sector economic activities. If one trusts that governments act on behalf of their constituents, then it follows that government planners must ensure that public undertakings are at least as valuable to the public as the alternative private sector activities that are displaced. Market values or prices are an obvious measure with which to evaluate private sector economic activities. They are also a useful measure of value for public sector projects.* Evaluation of such projects using market values and in particular discount rates that reflect market rates of interest and profitability can help ensure that public sector activities are productive in the sense that they make a positive net contribution to our well-being.

The private sector includes two basic decision making units - business enterprises and households. Together, they bear the burden of taxation. Both household and business activities are displaced by this taxation. The discount rate accordingly must capture the forgone value of either or both types of activities.

Business-enterprise incomes are used to undertake and sustain new investments. These investments in turn generate additional income as measured by a rate of profit (i.e. annual net income/value of the capital investment).

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* Market-based prices are determined by consumer values that are effective in the market, and by such factors as the distribution of buying power (income) and the competitive structure of industries. Such prices provide useful value information to the planner but may be misleading measures of social value under various circumstances. Prices may be altered by the planner or alternative non-market-based evaluation tools may be used in response to the need to capture social as opposed to market-based values. The use of altered or "shadow" prices is discussed in the report, Benefit-Cost Analysis Guide (March, 1976) which was prepared by the Planning Branch of the federal governments Planning Board Secretariat.

This profit is the benefit derived from business investments and it is the benefit lost when tax liabilities cause a potential investment to be delayed or abandoned. Assuming a profit rate of r and an investment of x dollars, the value of an investment after n years is:

$$x(1 + r)^n .$$

When x dollars of investment are displaced by tax payments which are spent on a public project, project cost is measured (using the carry forward formula) as:

$$x(1 + r)^n.$$

This measurement accounts not only for the actual cash outlay, x, but also the foregone private sector investment earnings.

An analogous argument can be made for households. Individuals can invest their income using financial vehicles in which case they earn revenues in proportion to financial interest rates. They can also invest their income in real assets like homes or other capital expenditures used for consumption purposes. From these real capital investments they reap an ongoing benefit in the form of services provided by the consumer assets, services like shelter, comfort, transportation, etc. In their allocation of income between financial investments and investments in consumer goods, households must strike a balance between interest earnings and the opportunity for direct consumption.* Interest rates like those on term deposits, bonds and mortgages reflect the trade-off that households are willing to make between interest earnings and consumption. They are equivalent to the profit rates of business enterprises in the sense that they measure the benefit derived from household investments. Taxes levied on households displace such investments. Public projects that use these

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* For many households, the balance is struck using financial liabilities rather than investments - i.e. current income is foregone through interest payments in order to increase consumption levels.

tax revenues should be shown to produce benefits that at least equal these foregone household benefits. Discount rates once again are used to measure such foregone benefits.

The preceding paragraphs pose the basic arguments used by economists to defend discounting in the economic analysis of projects. Economists go on at great lengths to elaborate on these arguments in order to develop prescriptions for the selection of a correct discount rate. A taste of this debate is provided in the Appendix by Dr. C. Southey; however, the reader may find the flavour somewhat frustrating since the debate is not resolved at all. Southey defends a discount rate of 6%, but is prompted by the uncertainty about the correct rate to suggest the use of a range about this rate that tests for sensitivity of the results of our analysis to the discount rate.

4. INFLATION AND THE DISCOUNT RATE

4.1. General

Conventionally, benefit-cost analysis is undertaken using "constant dollar" prices. These are prices measured in a single reference year and they reflect the purchasing power of the dollar in that year. The general impact of inflation is ignored. Inflation however, seems to have such a pervasive influence on our lives that the convention of ignoring its impact on prices requires some explanation.

It is necessary first, to point out what exactly is meant by inflation and how inflation relates to economic value. Consider a situation in which all prices including wages, salaries and other incomes are increasing at the same rate. In such a case, the value of any commodity expressed in terms of its exchange rate with another commodity remains unchanged. The purchasing power of incomes likewise do not change. The apparent change in prices is not based on any change in the real value of commodities. This is the kind of price change that is here called "general inflation".

The constancy of real commodity and resource values suggests that constant prices should be used for their evaluation in planning exercises. Inflating prices would imply erroneously that values are increasing with time.

Of course, the situation described above does not prevail. We observe numerous prices changing at various rates. While there is a general overall inflation rate measured for instance by the consumer price index, there is at the same time a continuous realignment of relative commodity values. Thus, constant dollar prices of certain commodities and resources are changing relative to other commodities. Notable recent examples of commodities undergoing these relative price changes are energy and gold. Such relative price changes, when they are significant and when they can be readily forecast, should be accounted for in planning studies.

4.2 Inflation, Saving and Borrowing

The picture sketched above is complicated by lending and borrowing transactions that are contracted at one point in time within a framework of known prices, but that entail commitments that extend into a future in which the price framework is uncertain. For example, home owners who mortgaged their properties 20 years ago at low interest rates now have benefited from what was an uncertain price future because increases in incomes and interest rates have far outstripped expectations. The burden of debt for these home owners has been drastically reduced by fortuitous price movements.

The feature here that complicates the analysis of section 4.1 is the introduction of savings or accumulated wealth as a commodity that can be bought and sold or rather rented out for a set term. The "rental fee" is the interest rate charged on a loan and it is a price paid to the holder of wealth to persuade him to transfer his claim over that wealth to the borrower for a specified length of time. The lender accepts interest payments in lieu of current opportunities for personal consumption or investment that he foregoes by lending out his money; for this reason the interest payment is said to be a measure of "time preference".

In a world where a price inflation is persistent, the owners of wealth will insist that interest rates account not only for their time preference but in addition that they make up for losses of purchasing power caused by general price inflation. The interest rate will therefore include two components: a time preference factor, and a factor measuring rates of inflation that are anticipated over the period of the loan. If time preference equals 5% and an 8% inflation rate is expected then the market rate of interest will be approximately 13%. Obviously, expectations are an important component in the market for loans. The lucky home owners described above were transacting loans in a market where expectations of future inflation were much too low. Current interest rates reflect inflationary expectations that are more in keeping with our recent experiences in the market place.

When interest rates anticipate inflationary pressures correctly, then an investment fund accumulating at a compounded rate (interest earnings reinvested in the fund) will not only retain its real purchasing power but will also show real increases in value proportional to the time preference rate.

There are two entirely equivalent approaches to the problems of discounting in benefit-cost analysis. The first uses inflating prices and a "nominal" discount rate based on interest rates that include the adjustment for inflationary expectations (13% in the example above). The second approach uses constant dollar prices and a "real" discount rate based on interest rates measured net of inflationary adjustments (5% in the example above).* In both these cases, the results of the analysis are the same and are based on constant dollar measures of value. The impact of inflating prices in the first procedure is fully and exactly offset by the inflationary component of the discount rate.

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* The terminology here seems inappropriate until one makes reference to the measure of value implied. Nominal rates measure the nominal or apparent but misleading inflating value. Real rates measure the underlying real values describing exchange values or real purchasing power.

To see this, consider our example from section 2

$$PV(x) = x/(1 + r)^n$$

where r measures the real discount rate and x is a cost, measured in constant dollars that occurs in n years. Assume a rate of inflation, i. The nominal rate, call it t, must make up for time preference and inflation. Thus:

$$(1 + t) = (1 + r)(1 + i)$$
$$= (1 + r + i + ri)$$

or

$$t = r + i + ri.$$

Since the cost, x, is expressed in constant dollar prices, the nominal cost in year n will be

$$x(1 + i)^n .$$

Discounting this value with a nominal discount rate, we have

$$PV(x(1 + i)^n) = x(1 + i)^n/(1 + t)^n$$

$$= x(1 + i)^n/(1 + r + i + ri)^n$$

$$= x(1 + i)^n/(1 + r)^n(1 + i)^n$$

$$= x/(1 + r)^n$$

$$= PV(x)$$

Nominal and real discounting procedures are thus identical.

4.3 Ignore Inflation?

Using the information provided above, this section will address some common arguments favouring a full accounting of inflation in cost benefit analysis.

a) Projects Cost More in the Future

"Projects cost more later on. These higher costs should be considered in planning". This is a very straightforward argument on the surface, but it can have different meanings and the rejoinder will depend on the intended meaning.

If the argument's reference is to the general rate of inflation then the appropriate response is that while it is true that all prices are increasing, it is also true that relative prices or real exchange values are constant. Constant dollar prices measure project costs in terms of the real productive resources that are used in project construction. They are the important measure of value in planning ard the measure upon which decisions should be based.

If, however, the argument about rising costs refers to relative price movements like those recently observed for energy resources rather than to general price movements, then the argument is well founded. Relative price movements should be considered in planning. This point is discussed in section 4.1 above.

Finally, the argument may entail an implicit comparison of inflating project costs and the non-inflating revenues of project proponents. This argument is considered below.

b) Project Financing is Easier Now

"Because of inflation it is easier to finance a project now than later, therefore we must take account of inflation in planning". This argument suggests that revenues are not inflating as quickly as project costs. In consequence the projects are becoming more expensive from the proponents point of view, even though the constant dollar cost is unchanged. Such projects would impose an increasing burden of debt on revenues as the date of implementation is pushed further into the future.

The kind of consideration posed here highlights the difference between benefit-cost and financial analysis. Benefit-cost analysis is meant to evaluate alternative projects strictly on the basis of the merits attributed to each by the affected persons. In our case the affected persons are the public and constant dollar market values should reflect their evaluation of marketed goods and services. Project selection should be made on the basis of these evaluations if it is to address the needs of the public. However,

due to the nature of financial markets and of political constraints imposed on the budget of agencies that would undertake large projects, there is a need for a financial analysis of projects that supplements benefit-cost analysis. Such analysis must consider for instance how new debt will affect the total debt burden of an agency and how this may in turn affect its credit rating and the cost of future loans. Inflation must figure in such an analysis and may well warrant a project construction date that is earlier than that justified by project benefits. On the other hand, tight limits on capital expenditures could result in lengthy delays of recommended projects. In either case the constraints imposed by financing problems can modify the recommendations arrived at on the basis of benefit-cost analysis.

Financial analysis of the sort described above inherently must focus on the short term and on specific project proposals. The uncertain nature of political constraints on budgets tend to make long term financial analysis rather futile. Moreover, financial analysis calls for detailed and accurate information regarding capital market conditions, project costs, cost sharing arrangements etc. Long term planning studies like the Grand River Basin Water Management Study cannot generate highly detailed financial information because the scope of the work is too broad and the planning horizon too distant. Benefit-cost analysis ignoring general inflationary pressures is the appropriate tool to use in studies of this sort that attempt to identify preferred long term courses of action in resource management. Financial analysis must come in at a later stage in the planning process during the implementation phase.

c) Low Debt Servicing Costs in the Future

"If we build now, the ammortized cost will end up being very low in the future" - i.e. we can benefit from inflation like the home owners described in Section 4.2. These home owners benefited from poorly anticipated inflation and correspondingly low interest rates. If this argument is true, this means that the current expectation for future inflation of about 10% reflected in the existing interest rates is too low! If it is not, then a debt assumed now will not be a "deal" later on.

d) Unaffordable Projects

"If inflation is ignored, projects will be recommended that no one will be able to afford". This is a variant of the argument under item (b) above, i.e. no one will be able to afford tomorrow's costs with today's incomes, but our incomes grow along with market prices, and so do government revenues. Indeed, over the long run, incomes have risen more rapidly than prices. If this trend continues, then chronic financing problems will not arise. At any rate, we cannot at this stage undertake a meaningful analysis of potential future financing problems (see section 4.2).

In summary it is easier and simpler to ignore general inflation in benefit-cost analysis, although the analysis with inflation gives results that are identical to the analysis without inflation. On the other hand, relative price movements should be considered when they can be forecast since they reflect changes in economic value.

APPENDIX

THE CHOICE OF THE DISCOUNT RATE FOR CANADIAN PROJECTS
A SHORT STATEMENT OF THE ISSUES

by

Clive Southey
Department of Economics
University of Guelph

1979

THE CHOICE OF THE DISCOUNT RATE

I. The need to discount future revenues and costs in public projects is based on a recognition that investments in the private sector that compete for inputs have positive rates of return, that is, there is an opportunity cost; and b) recognition that, all else remaining the same, additional consumption today is preferable to addition consumption in the future, that is there seems to be a time preference. Both components must be accounted for.

2. Fortunately these two forces are operative in capital markets as investors create a demand for funds thus revealing the opportunity cost, and savers bring forth a supply of funds revealing their time preference. Ideally the market for funds would achieve a full-employment equilibium where the productivity of another unit of investment just equalled the additional sacrifice of savers. The corresponding equilibrium rate of interest, the price of borrowing and lending, would be r_0 in figure I, and would be the appropriate social rate of discount: but with one major proviso.

3. The citizens who participate in the savings market are typically concerned with their own life-time consumption, while neglecting the concern for members of future generations with the exception, perhaps, of their own immediate offspring. There may then be a social need to supplement savings by government action (shifting the savings curve from S_0 to S_1 in figure 1 and calling for a lower discount rate which is sometimes referred to as the social rate of time preference.)

4. Putting aside this essentially political aspect of the problem, there remain several practical reasons as to why the current interest rates in fund markets may not be very useful.

It is generally acknowledged that private investment decisions are too volatile, being more concerned with short-term expectations as to the progress of the business cycle than the long-term needs of the economy. Hence we get the now orthodox (Keynesian) prescription for active manipulation of the rate of interest and control of the flow of funds onto capital markets via government borrowing. From this we learn that in cost-benefit practice we must refer to average rates over long periods.

5. An equally serious and far less easily overcome deficiency of the capital markets are the huge distortions introduced by government tax policies. As a consequence of the corporate profits tax, income taxes, capital-gains taxes, depreciation allowances, etc., there is a dramatic divergence between the interest earned by investors and that received by savers. In figure 2 the bite of taxes is represented by a downward shift of the investors demand from I_0 to I_2, and we now get not one but two rates of interest. The rate before taxes is r_c reflecting opportunity cost, and the rate after taxes is r_t reflecting time preference.

There is no consensus in the (extensive) literature as to which rate should be used, or if both are to be used, when and how should this be done. Since the differences in opinions largely reflect differences in assumptions as to how the economy and individuals behave, there is no obviously correct solution. Below we distinguish five schools of thought and five methods of discounting.

6. Method I: Use the Social Rate of Time Preference (See Arrow 1966, Kay 1972)

For the reasons cited in paragraphs (3) and (4) above, the market rates are considered to be of little help. In particular the private savings decisions are viewed as rigid habits or institutionalized norms, having little to do with true intertemporal needs and not sensitive to changes in the interest rates. The government should and can augment the flow of funds. It chooses a discount rate and then carries out all projects which have positive net benefits, financing the projects out of tax revenues.

Since the private rate of time preference is about 4% in Canada (Jenkins 1973), this method suggests discount rates of less than 4% are not undesirable.

7. Method II: Use the Opportunity Cost (Mishan 1974)

The adverse of this position is that governments are typically unable to augment the level of savings. Every time it attempts to do so by raising taxes, citizens, anticipating the benefits from the public projects financed out of taxes, simply reduce their own savings. This is particularly plausible when the investment project involves replacing a private economic activity with a public one - such as medicare. According to this line of argument since all government projects do is displace private production, the government must earn the same rate of return, hence we must use the opportunity cost, a rate in excess of 10% for Canada.

8. Method III: Averaging RTP and SOC (Harberger 1972) Dreze and Sandmo 1971)

Here a single discount rate is sought which is the weighted average of the RTP and the SOC, the weights depending on (a) the extent to which new capital is raised out of new saving and (b) the extent to which the project draws investment funds away from other sectors.

This method underlies the recent recommendations in the Treasury Board's "Benefit-Cost Analysis Guide", in which an average real discount

rate of 10% is suggested with a minimum of 5% and a possible maximum of 15%. The source of these numbers seems to be primarily Jenkins (1973) who estimates that of funds needed,

10% is from household saving at a RTP of 4%
16% is from housing investment at a SOC of 7.4%
10% is from foreign sources at a SOC of 3.15%
64% is from other investments in Canada at a SOC of 11.9%
(with manufacturing earning 15%)

9. Method IV: Separate Rates for Separate Functions. (Marglin 1963); Feldstein

This method uses only the RTP in discounting all 'costs' and benefits. The SOC enters into the computation of 'costs' which now include all the consumption that could have taken place had the funds been invested elsewhere at a rate equal to the SOC. In such a calculation, for Canada as a whole, the RTP would be in the order of 4% and the opportunity costs of funds would range from 7-15%, with a mean of say 12%. (Put differently, capital expenditures should be inflated upwards, or the cut off benefit cost ratio raised. Campbell,(1975) argues that with discount rates of 3.4%, a benefit cost ratio of between 1½ to 2¼ is desirable for Canada.

10. Method V: The Optimal Tax Method. (Diamond-Mirrlees-Little)

This method is relatively new. In broad terms it argues that SOC should dominate the discounting process, and generally requires that:

(a) All government projects should use the same discount rate;

and

(b) provided there are not significant monopoly profits in the private sector (which cannot be taxed away in lump-sum form), the rate for all government projects should be the same as in the private sector (in our case a SOC of 12%);

but

(c) if the economy and/or government is free to borrow all it needs on international markets, then the rate should equal the international borrowing rate, (which Jenkins estimates at 3.15%!)

There are some important qualifications to Rule V-(c), namely (i) that the country is not experiencing difficulties in accepting current exchange rates and (ii) that the government does not face unwanted limitations on the size of its budget, (iii) that the amount of Canadian borrowing does not influence the interest charge. Since all these problems are present to some degree, the rate of 3.15% for Canada may be somewhat on the low side.

Note that in Method V the RTP does not enter directly into the C/B Study, for it is assumed that the choice of tax rates (personal, indirect and corporate), as well as financing decisions, have already incorporated the concern for the future. In short it assumes all taxes are ideally determined

On the other hand in broad terms, Rule V(c) still applies to the public sector even if some taxes are not ideal, (provided the extent of government borrowing is not unduly restricted, as noted).

11. Choice of Method in This Study

Methods I and II are crude but each serves to highlight the empirical and value judgements that favour low or high rates. Method V is the most compelling, though it has clearly not yet influenced the Federal Treasury Board (perhaps because until recently the Federal Government has made relatively little use of foreign borrowing). It has a strong prescriptive function indicating the need for coherent tax policies, and the overwhelming importance of foreign borrowing rates. However, in view of the relatively recent arrival of this contender, and the uncertainty as to its

applicability, we prefer to use one of the more traditional methods, while bearing in mind that Method V argues strongly for relatively low discount rates.

The use of Method IV is perhaps theoretically superior to Method III, though recent theoretical writings argue that the difference between them is more apparent than real. On the other hand the simplicity of a single discount rate, and the more intelligible criteria of a cut-off benefit cost ratio of unity, makes the average discount rate method the most practical. Methods I, II and III all draw attention to the importance of financing, and in this respect the aforementioned application of Method III by the Federal Treasury Board, makes a serious omission in that it assumes no financing takes place through current taxes! The following Section 12 shows how, using Jenkins estimates for the SOC of various sources of finances, one can construct an average discount rate to incorporate financing out of taxes.

12. Figure III is a simple, somewhat stylized, schematization of the consequences of a decision by government to invest $1.

Four basic sources of finance are noted namely (i) direct (income) and indirect taxes; (ii) corporate and business profits taxes: (iii) domestic and (iv) direct foreign borrowing. Let us consider the consequences of each of these.

a) If t_y is the fraction of expenditure financing out of direct and indirect taxes and are largely paid by households, and if S is the fraction of additional income that households tend to save, then $(1-S).t_y$ is the decrease in consumption caused by increased household taxes, and is shadow-priced at RTP. The consequences of the decrease in savings of St_y is to put pressure on the market for funds, and is considered in (d) below.

b) If t_b is the fraction of government revenue financed out of business and profits taxes, and ϕ is the fraction of corporate profits after taxes that are distributed to shareholders of which $(1-S_b)$ would have been consumed, then the direct effect on consumption is $[T_b.\phi.(1-S_b)]$ and we shadow-price this at RTP. Savings out of distributed profits decrease by $[T_b.\phi.S_b]$ which puts pressure on funds markets (see (d) below). Undistributed profits decrease by $T_b\ (1-\phi)$, resulting ultimately in capital losses, and ignoring capital gains taxes for simplicity, of this same fraction, S_b would have been consumed, shadow-priced at RTP, while the remainder comes from lending (in (d) below).

c) Let b_f be the fraction of revenue raised in foreign markets. This has a price of SOC_f. The remaining fraction of revenue $(1 - r_y - r_b - b_f)$ will come from the general funds market.

d) Pressure is put on the Canadian bond equity markets from decreases in household savings; from decreases in shareholder saving and corporate internal financing; and from government borrowing. Let π be the sum of all these, as a fraction of total expenditure. Following Jenkins we assume that the response of the funds market is to provide 10% out of new savings, (priced at RTP); 10% out of foreign borrowing (priced at SOC_f); and 80% out of decreases in Canadian investment (priced at SOC).

The sum of items (a)-(d) gives us a weighted average discount rate. Assuming $\phi = .5$; $S = .10$; $S_b = .50$; and that 10% of additional government revenue will be financed out of increases in corporate profit

taxes, we have estimated the discount rate for various financing decisions, that is, variations in personal direct and indirect taxes (t_y) and in the fraction of remaining borrowed funds coming from overseas (b_f).

In 1975 and 1976 personal and indirect taxes accounted for 75% of the revenue of all governments (excluding intergovernment transfer) and 70% of the revenue raised by Provincial governments. Foreign borrowing only accounted for about 7% of all government revenues, but approximately 16% of Provincial revenue. Using these figures, and setting RTP = 4%, SOC = 12% and SOC_f = 3%, we find for all governments with t_y = 75% and b_f = 7%, the computed discount rate is 5.3%. Using the provincial data, so that t_y = 70%, b_f = 16%, the computed rate was 4.85%.

The above estimates assume, in the spirit of the Treasury Board, that if another dollar is spent by government it will be financed in the same way as all previous dollars. It seems very reasonable, however, to suppose that the government tends to resort to borrowing to make up for the difference between predicted revenues (at existing tax rates) and expenditures, and that this might particularly be true if the additional expenditure is to be for capital investment. Similarly, one might suppose that, having made use of limited Canadian Sources of funds, the tendency is to finance a large amount of additional borrowing from foreign markets. Note that in 1975 and 1976 and 1977, Governments at all levels borrowed more overseas than their entire deficits, implying an extreme preference to finance debt overseas rather than from Canadian sources. Table 1 shows how the discount rate should vary were the government to (implicitly) fund additional funds along such lines. Thus for example, if only 20% of additional funds were financed out of increase in personal and indirect taxes,

10% from additional corporate taxes, and the remaining 70% from foreign sources, the appropriate rate would be 3.6%. (If however only 10% of the funds were borrowed overseas, the rate would be 8.1%).

DISCOUNT RATE AS A %*

b_f \ ty	Percentage of revenue raised out of personal and indirect taxes				
	0%	20%	40%	60%	80%
% of revenue raised out of foreign borrowing. 10%	9.3	8.1	7.0	5.9	4.7
30%	7.8	6.7	5.5	4.4	n.a.
50%	6.3	5.2	4.1	n.a.	n.a
70%	4.9	3.7	n.a.	n.a.	n.a.
90%	3.4	n.a.	n.a	n.a.	n.a.

TABLE I

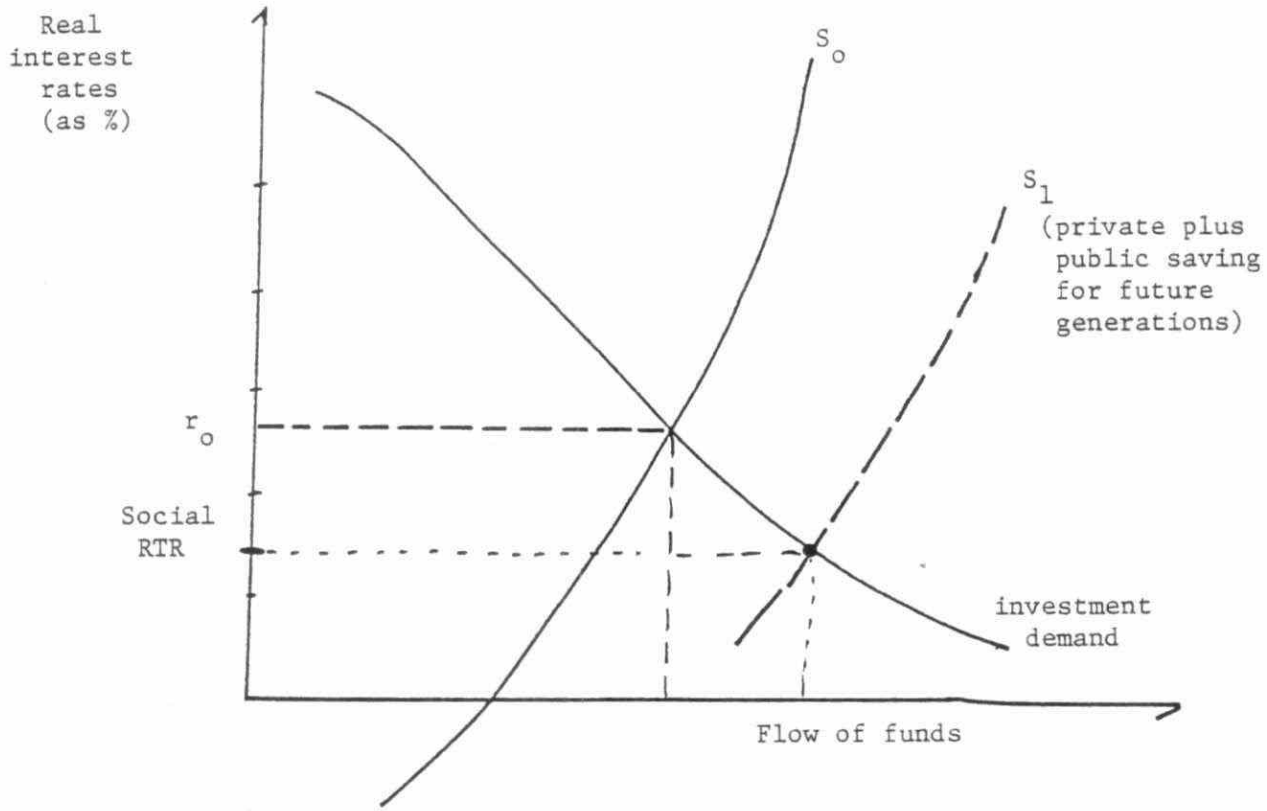
* Assumes $S = .10$, $S_d = S_b = .50$; $\phi = .50$ and $t_b = .10$.

13. Conclusion

From the above analysis we conclude that the discount rate of 6% with a range of 4% to 8% is quite appropriate. Though rates of 9% and above are conceivable, they seem too high for given existing finance patterns. A rate

of 3% is probably too low, given current restrictions in foreign exchange markets, but it must always be borne in mind that, as noted in method I, the RTP should also reflect the value judgments of the decision makers as to whether the needs of future generations are being adequately taken care of. In the absence of a comprehensive policy as to the savings patterns of Canadians, it seems likely that conservation authorities have a particular moral obligation to defend the interest of the future.

FIGURE 1



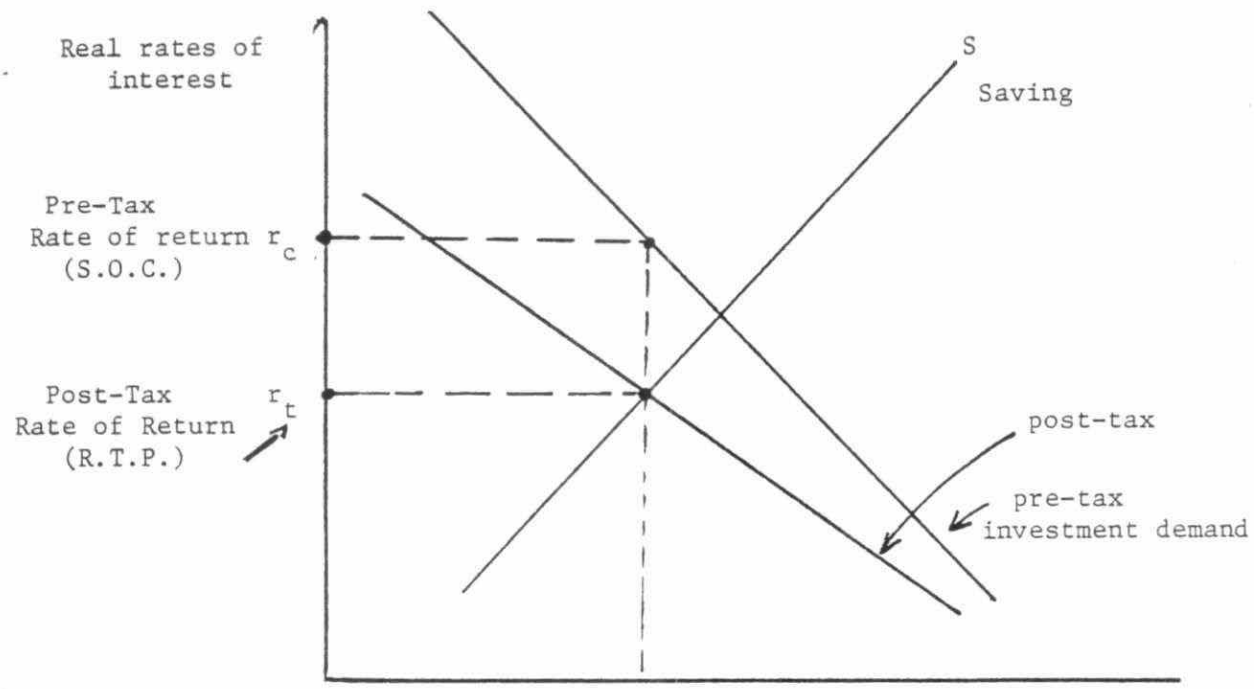
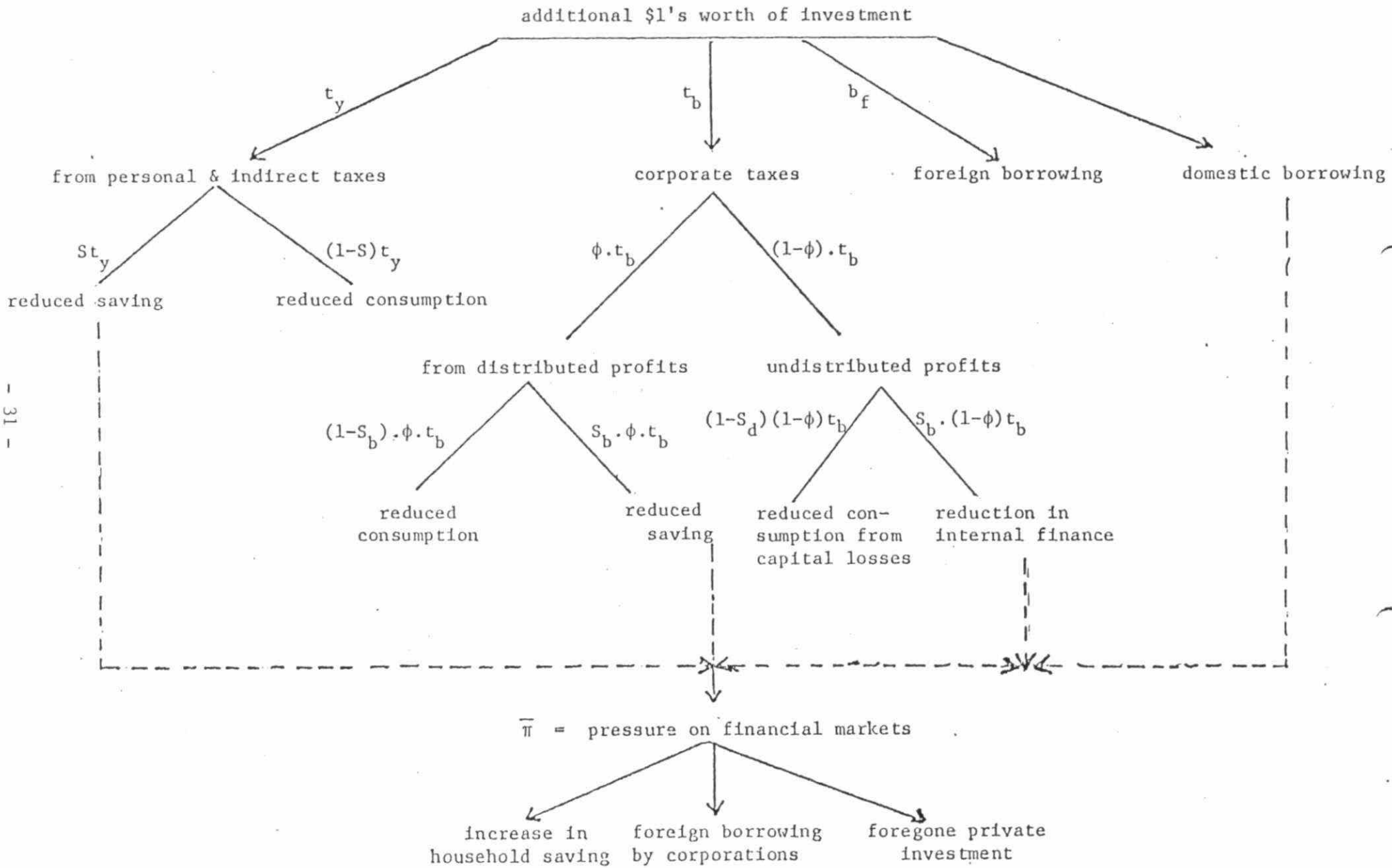


FIGURE 2

FIGURE III


additional $1's worth of investment
t_y
t_b
b_f
from personal & indirect taxes
corporate taxes
foreign borrowing
domestic borrowing
St_y
$(1-S)t_y$
reduced saving
reduced consumption
$\phi.t_b$
$(1-\phi).t_b$
from distributed profits
undistributed profits
$(1-S_b).\phi.t_b$
$S_b.\phi.t_b$
$(1-S_d)(1-\phi)t_b$
$S_b.(1-\phi)t_b$
reduced consumption
reduced saving
reduced consumption from capital losses
reduction in internal finance
$\bar{\pi}$ = pressure on financial markets
increase in household saving
foreign borrowing by corporations
foregone private investment

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